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EXTENDED AIR DEFENSE TESTBED: SPECIFIC SYSTEM REPRESENTATION (SSR) DEVELOPMENT

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Abstract

The Extended Air Defense Testbed (EADTB) provides an object-based simulation system to support analysis of current and future extended air defense systems as they interact with present and evolving aircraft and theater missile threats. The architecture of the EADTB maps real world objects, such as aircraft, missiles, and radar, into software simulation objects by decomposing them into four major components.

- Thinker Component - the brain of the object, which performs the basic functions of, observes and decides.
- Platform Component - the physical structure of the object
- Communicate Component - the means of passing data from one object to another
- Sense Component - the means of seeking data of other objects or conditions external to the Platform

The software objects are linked together through data definition to create representations of real world systems, known in EADTB as Specific System Representations (SSRs). An SSR contains only one Platform component and at least one Thinker component.

The data which comprises an SSR essentially defines the physical characteristics of the represented system, such as the ability to move (including movement characteristics), the ability to detect, to generate signature, and to harm others. The ability to plan, coordinate, and react is contained within the Thinker component rule set.

How is EADTB different from other simulations?

The EADTB offers a robust, user-flexible representation of weapons systems, sensors, and C4I systems in a state-of-the-art synthetic environment for NMD and TAMD analyses. The EADTB offers a number of special capabilities, which, in combination, set it apart from other simulations:

1. EADTB partitions perception from truth and propagates perception, whereas many simulations propagaate truth and add errors to represent perception. EADTB simulates the real-world processes of sensors generating perceived data and thinkers making decision based on those data.
2. The EADTB has an extensive verification and validation (V&V) legacy for library-resident specific system representations (SSRs) and for the common model set, which provides the "building blocks" for user construction of SSRs.
3. EADTB allows users to build their own SSRs, as well as use existing SSRs from the master library. In most other simulations, the user can only set flags or modify numerical data inputs to alter the behavior of built-in system representations. When built-in representations cannot meet user needs, most other simulations must be modified by the developer or altered at the source-code level by the user, which can negate any existing V&V verification.
4. The EADTB offers a high degree of flexibility in defining the detail of SSRs, communications models, environment models, and the scope of the scenario. Scope can include theater level for TAMD, global level for NMD, or simply fire-unit level for one-on-few simulations. In addition, EADTB can mix different levels of detail in a single experiment. For example, EADTB could simulate NMD activities at low detail, theater wide TAMD at low detail, and a single fire unit or ship

defending a critical theater "choke point" (e.g., a sea port at a relatively high level of detail (e.g., 3DOF flyout, a dynamic sensor with Kalman filter, extensive C2 rule sets, and explicit communication message format representations).

5. The EADTB offers the capabilities to model command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) at a very high level of detail for a theater/global-level simulation.
6. The EADTB offers a robust suite of on-line tools for visualization and numerical diagnostics. Visualization capabilities include runtime and playback display in two-dimensional (map) view and three-dimensional view. Playback allows continuously variable forward and reverse speeds. A full suite of spreadsheet tools and statistical diagnostics can operate on user specified measures of performance. An external stealth view can easily be added by exploiting the EADTB's DIS compliance.

SSR Development

SSR development follows the normal flow for real system development. The specific system to be modeled for a study is decomposed into its most basic functions applicable to the study objectives. These functions are collected into a set of requirements for the specific system model for this study. Requirements levied against the SSR should be developed/modified for the study. These SSR requirements are allocated against the SSR data and rule set. The requirements against the data are used to collect appropriate data and/or derive necessary data. Rule set development can follow software development processes. The rule set and data are integrated and tested on the EADTB within a small scenario to identify any problems. Finally, the SSR is integrated and tested in the study scenario.

The EADTB consists of an array of software modules linked through data values defined during Experiment Preparation. The linkage of these modules allows a wide range of weapon systems to be modeled, with an emphasis on air defense. There is a great deal of flexibility in the modeling of these systems. For example, the user has access to many predefined SSRs contained in the master library, or the user can construct completely unique, even hypothetical systems, by defining parametric performance data for a system and the decision-making logic to control its actions. An SSR is defined with these two elements: 1)SSR data sets – parametric data which describe the functionality of the system; and 2)SSR rule sets- governs which model the decision-making logic of the system.

How Rule Sets Apply to the Model

Every SSR has one Platform, one or more Thinkers, and zero or more Sense and Communicate components. While the Platform, Sense, and Communicate components perform all of the physical functions of the modeled systems, all of these functions are orchestrated by the Thinker component. Thinker can be thought of as a knowledge-based executive, accepting perceived data as input, and generating action, based on this data, as output. Thinker has access to data including assets, command hierarchies, tracks, zones, and weapon resources. The Thinker component contains decision logic, known as its rule set, which it uses with this data to decide on appropriate commands to issue to other components, and how to process data received from them.

How Data Sets Applies to the Model

The SSR data sets contain all of the parametric data needed to define the operational characteristics of the modeled system. The type and extent of data required depends on the type of system being modeled. The data required to model a ballistic missile would be less than that needed to model a guided missile with an infrared (IR) seeker.

The Thinker parameters include performance data for kill assessment, guidance, weapon engagement, threat assessment, data fusion, and command reporting hierarchies. The Platform data consists of all the data needed to model the functions of Platform – move, carry/launch, generate signature, and impair/assess damage. The Communicate data consists of message protocol and format data, message tables, and connectivity data, including nodes, networks, and gateways. The Sense data consists of all the transmitter, receiver, tracker and discriminator

performance data.

SSR Requirements

Specification of requirements for EADTB SSRs is similar to the specification process for individual and aggregated representations in other simulations. The analyst must consider study requirements and actual weapon system requirements to identify required control logic, input data, output data, measures to be quantified, levels of accuracy required, and any sensitivities that must be explored. Sensitivities may be dictated by Measures of Effectiveness and Performance (MOEs/MOPs), Essential Elements of Analysis (EEAs), Critical Operational Issues (COIs) or Critical Questions and Issues (CQ&I) of the study that the model must address. Levels of detail and aggregation are often traded-off, driven by the model's execution speed (i.e. required amount of time to process all runs) and/or the study analysis requirements.

SSRs also have requirements for compatibility and interoperability with each other, which are driven by the EADTB software models. Each SSR must be capable of supplying other interacting SSRs required data and triggers. These items include parametric data such as signature and lethality. Communication between SSRs must be integrated between transmit and receive capabilities, message formats, and protocols. These interoperability requirements alone can drive the detail and accuracy of SSR specifications.

SSR Integration and Test

The SSR Integration and Test (I&T) is performed by the developer. The test vignette defined during the preliminary design phase is used during the SSR I&T to verify the functional requirements allocated to the SSR, as well as the external interfaces. It is recommended that new SSRs be tested in sections. With successful integration, actual modules of the SSR are coded in proper sequence. This iterative process continues until all requirements and interfaces of the SSR have been integrated with the test scenario. After the SSR has been successfully integrated and tested, a test walk-through is conducted.

The following criteria are used for internal review of the I&T design:

- Ensure all functional requirements are tested.
- Ensure all interfaces, both internal and external are tested.
- Ensure adequate test coverage of interfaces (minimum, maximum and representative value).

Initial SSR I&T may be accomplished by use of internal prompts. This level would serve to basically integrate and minimally test the Platform and other attached components of the SSR. For example, prompts could be established during the Start_Up event to trigger required rule set processing, which would result in subsequent commands issued to components component data access and retrieval, and the setting of additional prompts.

Further SSR I&T is accomplished by us of a scriptor SSR. This level serves to integrate and minimally test message reception processing in the tested SSR. The scriptor's rule set needs to be written such that all messages expected by the tested SSR's rule set are transmitted. Message transmission is accomplished via prompts, via Command_Complete processing, or a combination of both. Message reception processing is then monitored and evaluated in the tested SSR.

Final I&T is accomplished by deploying the subject SSR in a test scenario with other SSRs. At this level, complete testing of all functional requirements, interfaces, and internal processing is possible. Much of the internal processing and interface testing was completed using internal prompts and scriptor SSRs. The bulk of test during this phase is concentrated on functional requirements.

The EADTB offers a robust, user-flexible representation of weapon systems, sensors, and C4I systems in a state-of-the-art synthetic environment for raid and multiple-raid analyses.

Systems Represented in EADTB

Specific System Representations (SSRs) are user constructed, so any system falling within the general classes of Guided Missile, Ballistic Missile, Orbital Space Object, Winged Airborne Movement Object, Sea Based Movement Object, and Ground Movement Object either are, or can be, represented. Developers and users have already constructed a variety of SSRs associated BM/C4I. Recently completed SSEs have assisted in the assessment of space information operations communications/data fusion centers and their associated surveillance and shooters. Verification of SSRs is an on going process. A master list of all SSRs can be obtained from myself, 256-955-1650.

Verification & Validation Program for EADTB

The TPO has had an Independent V&V (IV&V) program and dedicated contractor since 1993. In addition, experts from the SETA team have also been used to perform independent V&V. the V&V includes code verification, detailed algorithm analysis, and output validation activities. The IV&V contractor has completed detailed analysis reports covering the following areas: communications, sensors, ballistic missile prediction, missile guidance, data tracker, and plot processing. Regression testing is performed on new releases of the software and updated reports are submitted as required. The IV&V contractor has tested over 4000 requirements to date.

The IV&V team performs both structural and output validation on EADTB. Structural validation focuses on the architecture and algorithms of the EADTB in the context of their intended use. The individual functional areas areas are evaluated to ensure that they adequately represent the real systems being modeled. The algorithms are validated to be correct and consistent with established theory. Analyses are performed to ensure that variations in the inputs produce correct results in the outputs. The total simulation is assessed for completeness and correctness. Output validation involves comparing EADTB results with real test data. The IV&V team utilizes data archived in the Midcourse Data Center and other data centers to perform output validation.

Current Users of EADTB

United Kingdom (UK), MOD; Germany, IABG; The Netherlands, NATO Consultation, Command and Control Agency (NC3A); NATO Medium Extended Air Defense System Management Agency (NAMEADSMA); USAADSCH, Ft Bliss TX; USNSWC, Dahlgren VA; USAF TACCSF, Kirkland AFB NM; BMDO, 4 sites in Washington DC area; USAAMCOM, Huntsville AL; USASMDC ARC 3 sites, Huntsville AL; Warfighter Analysis Integration Center (WAIC), Arlington VA; Lockheed Martin Missile and Space, Huntsville AL (1 in AL and 1 in FL); SAIC, McLean VA; Raytheon Systems Company (RSC) Software Development Facility (SDF), Huntsville AL; USASMDC simulation Center, Huntsville AL

Training, Cost & Equipment

An EADTB/Analysts require one week of formal training and three to six months of hands-on experience, depending of the background of the individual to be trained and whether the individual will be developing and/or modifying SSRs. For additional information on EADTB training contact Raytheon Systems Company (Mr. Rich Stubblefield 256-971-2533) or the TPO (Mr. Robert Karl 256-955-1685) to get dates of classes and associated costs.

An EADTB system with up to two workstations costs approximately $162K, but cost will vary depending on the number of software licenses needed and the number of peripherals and additional work stations required. Maintenance cost is approximately ten percent of purchase price per year of operation.

Hardware and Software cost for a typical EADTB Site

A typical EADTB site includes an EADTB host system, at least two EADTB workstations, system software, and

various commercial-off-the-shelf (COTS) software packages used in configuration with EADTB and Peripherals. Currently, the recommended EADTB host system is a Silicon Graphics Origin 2000, with 4x250 MHz MIPS R10000 CPUs, 2GB RAM, 6x9 GB SCSI Disk Drives, a SCSI XIO card and external vault, fast ethernet interface, CDROM and 4mm DAT Drive. The recommended EADTB workstation is a Silicon Graphics 02, with 1x200 MHz MIPS R10000 CPU, 384MB RAM, 1x4.3GB SCSI Disk drive and fast ethernet interface. The EADTB software configuration requires IRIX Operation System and NFS for both the EADTB host system and the EADTB workstations. The COTS packages include Oracle RDBMS Version 7.3.3 with SQL Plus (including SQL Net and TCP/IP), PV-Wave Advantage 6.1 and Applix Base and Spreadsheet 4.3.786.5. Recommended peripherals include a PostScript Laser Printer and Color Printer, A network fast ethernet and a DLT automatic back-up system. The Testbed Product Office (TPO) is also studying use of the Silicon Graphics Octane, at a greatly reduced cost, but which will only support one workstation.

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